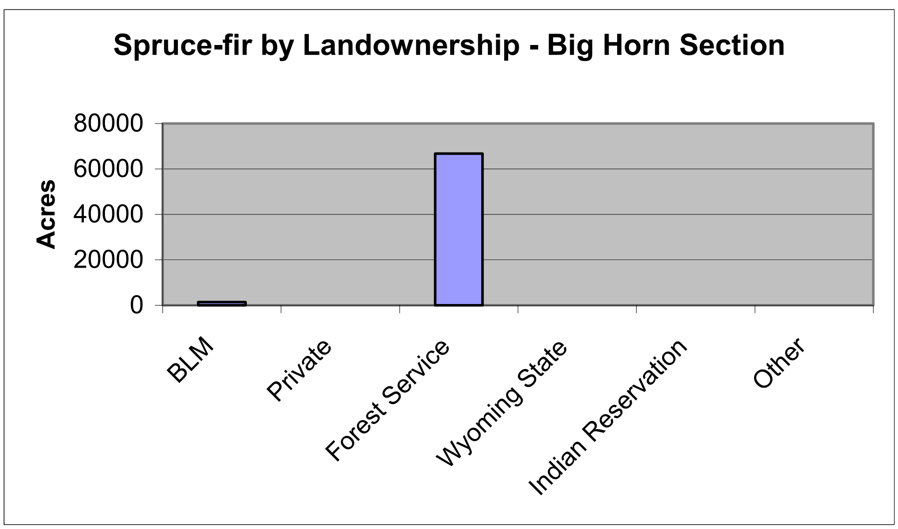
Forested Vegetation – Spruce-Fir

Engelmann spruce (Picea engelmannii Parry ex. Engelm.) and subalpine fir (Abies lasiocarpa (Hook.) Nutt. var. lasiocarpa) (Nelson and Hartman, 1984) forests are the second most dominant cover type, and most dominant habitat type, in the Big Horn mountains. While some of the literature differentiates between Engelmann spruce and subalpine fir, most notably Hoffman and Alexander (1976) and the potential natural vegetation mapping in this document, their ecology and distribution is so intertwined that the following existing vegetation discussion will largely focus on the “spruce-fir” forest. Describing the Abies lasiocarpa series, Hoffman and Alexander (1976) state:

> “The habitat types described in this series are all named for *Abies lasiocarpa* as the climax dominant to be consistent with common usage (Daubenmire and Daubenmire 1968). In the Bighorns, Picea *engelmannii* is a coclimax dominant, with little evidence that it will ever be completely replaced by *A. lasiocarpa*.”

Table A1 shows the distribution of spruce-fir forests across land ownerships in the Bighorn Mountain subsection. The Bighorn National Forest manages nearly all of the spruce-fir forests in this subsection. This is GAP data, and does not match acres with the CVU cover type data, but the percentage by ownership is the important piece of this table.

Table A1. Spruce-fir Cover Type Landownership - Big Horn Mountain Section



White spruce (Picea glauca (Moench) Voss) is known to occur in the Big Horns (Nelson and Hartman, 1984). However, for this paper it will be used interchangeably with Engelmann spruce, for several reasons. Little is quantitatively known about its distribution in the Big Horns, it hybridizes with Engelmann spruce (Walt Fertig, personal conversation, 1999; Hoffman and Alexander, 1976), and the ecological literature overwhelmingly discusses Engelmann spruce. Future investigation into the abundance and distribution of white spruce in the Big Horn Mountains is warranted.

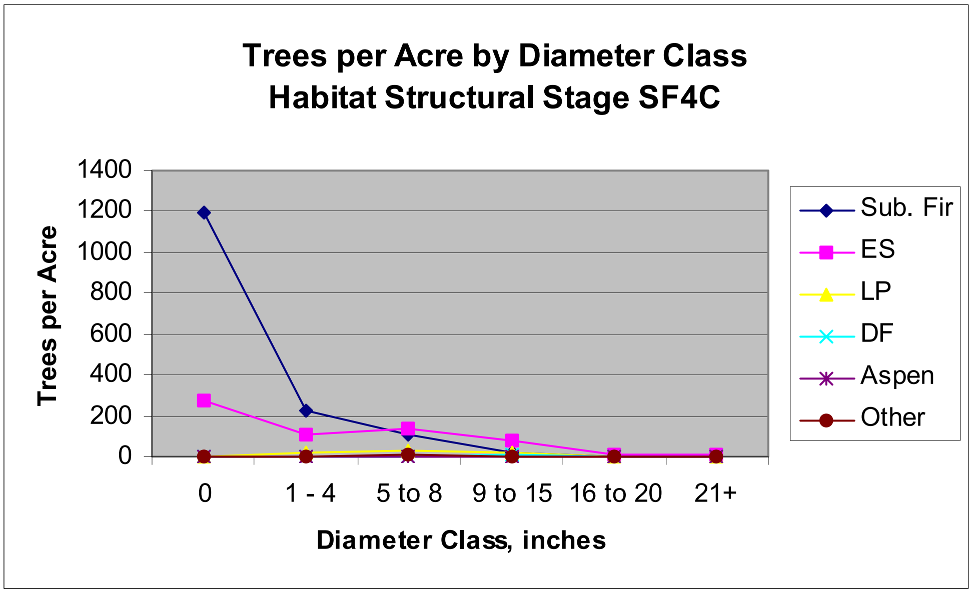
Engelmann spruce is the largest high elevation species that occurs in the Big Horn Mountains. Individuals can reach 45 inches diameter, and 20 to 25 inch overstory stand average diameters occur (Bornong, personal observations). Engelmann spruce is a long-lived tree, maturing in about 300 years. Dominant spruce are often 250 to 450 years old, and trees 500 to 600 years old are not uncommon. (Alexander, 1987) 550-year-old spruces are known to occur on the Big Horn near Powder River Pass (Bighorn NF records). Engelmann spruce is considered to have a shallow root system (Alexander, 1987).

The regeneration requirements for Engelmann spruce have been much studied in the Rocky Mountains. The basic requirements for successful natural regeneration include: (1) an adequate supply of viable seed, (2) a suitable seedbed, and (3) an environment compatible with germination and initial survival (Alexander, 1987). Alexander and Sheppard (1984) quantified 14 conditions as favorable and unfavorable for natural regeneration of spruce. Subalpine fir is considered slightly more shade tolerant than Engelmann spruce, as 40-60% of full shade is most favorable for spruce establishment, while over 50% full shade will favor fir over spruce (Alexander, et al, 1984; Alexander and Sheppard, 1984). Precipitation during the July to August growing season is also critical in establishment of Engelmann spruce; over 0.5 inches per week is considered favorable. Precipitation during July and August in the Big Horn mountains is primarily in the form of afternoon thunderstorms, which are quite sporadic as to timing and intensity. Review of precipitation data from the Powder River station for July and August of 1979 to 1995 showed that the favorable (over 0.5 inch) condition occurred in 24% of the weeks. No precipitation occurred with the highest frequency, 27% of the weeks (Bornong, 1996). Shade and precipitation are only two of the 14 factors that have been quantified for Engelmann spruce regeneration, and the others are covered in depth in the cited literature.

The most prominent insect and disease threat to Engelmann spruce in the Big Horn Mountains is the spruce beetle, *Dendroctonus rufipennis* (Harris, et al, 1998). Spruce beetle populations associated with blowdown trees were detected in Big Horns in the 1970’s and 1980’s. Although the level of spruce beetle is at endemic levels, there were some moderately large pockets of spruce mortality within the Little Bighorn area (Harris, et al, 1998). The areas studied included areas in and near the 1993 blowdown event, which is the highest risk area in the Big Horns at this time.

Subalpine fir on the Bighorn can range from the treeline krummholz growth form (Knight, 1994), to closed forest conditions with diameters of up to 20 to 24 inches (Alexander, 1987). While subalpine fir can live to be 300 years old (Aplet, et al, 1988), mortality often occurs in the 125 to 175 year old age classes, likely due to susceptibility to a variety of insects and diseases (Schmid and Hinds, 1974). Subalpine fir reproduction is considered to be much more effective than Engelmann spruce in the forest environment (Knight, 1994), and is evidenced on the Big Horn from Table A2, which shows the trees per acre by diameter class distribution. This data is from the Big Horn Stage I inventory points, and while this table shows data from one habitat structural stage, the other structural stages show the same pattern. The number of subalpine fir seedlings less than one inch diameter at breast height exceeds the number of Engelmann spruce seedlings by a margin of 4:1.

Table A2. Trees per Acre by Diameter Class for Spruce-fir Habitat Structural Stage 4C.



While “fir decline” is widespread throughout the spruce-fir forests of the Rocky Mountains, the subalpine fir in the Big Horn mountains currently enjoys the highest level of this mortality causing agent in the Rockies (Kurt Allen, personal conversation, 2001). The “near outbreak level” of fir decline activity cited in the Little Bighorn Area (Harris et al, 1998), is now considered to be at outbreak levels throughout the Big Horn Mountains (K. Allen, personal conversation). Fir decline is caused by a combined effort of the western balsam bark beetle (*Dryocetes confusus*) and root pathogens, suspected to be either *Armillaria* spp. or *Annosus* (Harris et al, 1998). This complex has been known to be active in Rocky Mountain forests since at least 1965 (Schmid and Hinds, 1974).

COMPOSITION

Driving factors influencing composition

Numerous environmental influences dictate where spruce-fir forests occur. These factors interact with each other, creating environmental continuums that result in a complex spatial pattern of species distributions. Among these are:

- Elevation
- Aspect
- Soil substrate
- Precipitation patterns
- Topographic position

- Temperature

Engelmann spruce and subalpine fir forests have relatively low water use efficiencies, and require relatively large amounts of water (Knight, 1994). Therefore, areas with cooler, more mesic environments are more likely to support spruce-fir forests.

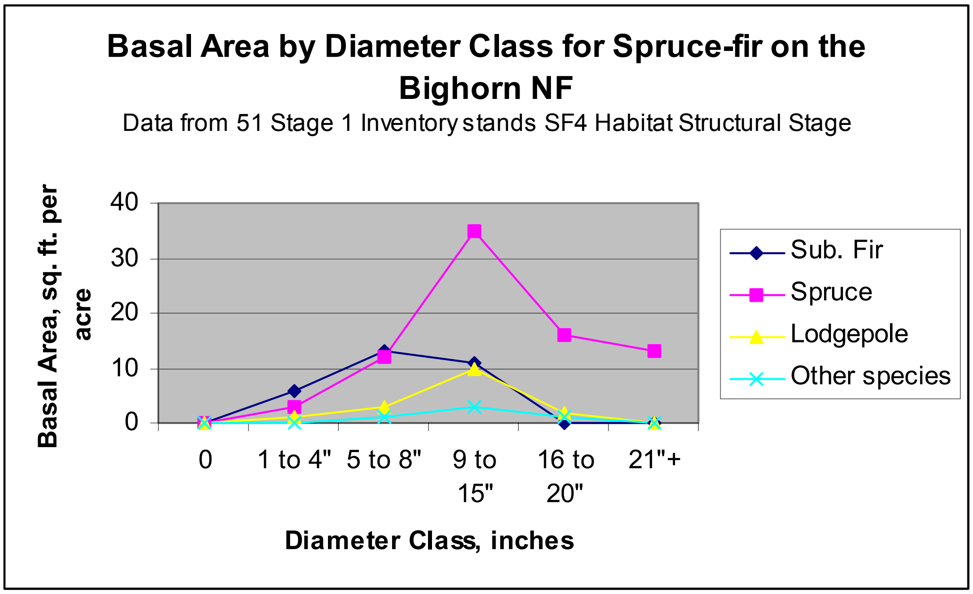
Despain (1973) lists several factors affecting the distribution of spruce-fir forests on the Big Horn mountains:

- Spruce-fir forests on the Big Horn mountains occur from about 2300 m to timberline at 3050 m, but are most common between 2600 and 2900 m.
- A timberline fringe of spruce-fir occurs around the highest granite peaks, where the unfavorable granite conditions are ameliorated by the high elevation.
- Spruce-fir forests are best developed along north-facing slopes, especially on Gros Ventre shale on the northern third of the range.
- The mean water content of snow on May 1 for the Big Horn mountains is highest over the north portions of the range, where the relative abundance of spruce-fir is high. Most of the year's moisture supply is present in the form of snow about May 1.
- By plotting data according to east or west flank and according to granite or sedimentary substrates, Despain found:
    - On granite, the only association for spruce-fir was that it is found at high elevations.
    - On sedimentary substrates, the west flank of the Bighorns is dominated by non-forest communities, and spruce-fir forests are not very important. On the east flank, forests dominate and spruce-fir is the best developed.
- Aspect-substrate associations are:
    - Spruce-fir stands are negatively associated with south aspect slopes on sedimentary substrates.
    - Spruce-fir stands show no positive association with any aspect on granite substrates.

Considerable attention has been given to the dynamic complexity of spruce-fir forests, and how Engelmann spruce can maintain its co-dominance in these forests, despite subalpine fir's prolific reproduction and slight advantage in shade tolerance (Knight, 1994). Table A2 above shows the number of trees per acre advantage that subalpine fir maintains until about 4" dbh. This table is from Bighorn NF data, but is typical of other spruce-fir forests throughout the Rocky Mountains. Table A3 shows how basal area varies by species and diameter class. As with trees per acre, subalpine fir as quantified by basal area holds a slight advantage in the smaller, understory diameter classes, while Engelmann spruce dominates the total basal area and the overstory canopy. On the Big Horn, Hoffman and Alexander (1976) concluded that Picea *engelmannii* is a coclimax dominant, with little evidence that it will ever be completely replaced by *A. lasiocarpa*.

In general, the co-dominance of Engelmann spruce and subalpine fir over time has been largely attributed to the fact that subalpine fir is a prolific reproducer, but has a significantly shorter life span, especially because it is susceptible to a host of insects and diseases (Veblen, 1986). The relative proportion of each species changes over time, and according to Aplet, et al (1988), this within-stand relationship is predictable over time. Following a stand replacing event, spruce and fir both colonize the site. (This model assumes there is no lodgepole seral stage.) After one to two centuries, a period labeled the "spruce exclusion phase" occurs, when spruce can no longer reproduce in the understory. After another century, many of the dominant fir and spruce begin to die, initiating the "spruce reinitiation phase", when canopy gaps create favorable conditions for spruce reproduction. The final phase is a "second generation spruce-fir forest", which lasts until the next stand replacing event.[1]

Table A3. Basal Area by Diameter Class in Spruce-fir on the Bighorn NF



[1] This summary of Aplet et al (1988) is from Knight (1994).h

Major species/plant associations

Plant associations recognized by Hoffman and Alexander (1976) include:

Hoffman and Alexander (1976) Habitat Type	***Pseudotsuga menziesii***	Pinus contorta	***Picea engelmannii***	***Abies laxiocarpa***	**Other important species**
P. engelmannii/Vaccinium scoparium	s	S	C		*Juniperus communis, Antennaria racemosa, Arnica cordifolia, Epilobium angustifolium, Fragaria viginiana, Lupinus argenteus, Rosa acicularis, Senecio streptanthifolius, Poa nervosa.*
A. lasiocarpa/Shepherdia canadensis	s	S	C	C	*Juniperus communis, Berberis repens, Linnaea borealis, Spiraea betulifolia, Rosa acicularis, Pyrola secunda, Arnica cordifolia*
A. lasiocarpa/Vaccinium scoparium	s	S	C	C	*Poa nervosa, Antennaria racemosa, Arnica cordifolia, Epilobium angustifolium, Lupinus argenteus, Fragaria virginiana, Potentilla diversifolia, Pyrola secunda*
A. lasiocarpa/Arnica cordifolia	s	S	C	C	*Ribes lacustre, Poa nervosa, Antennaria racemosa, Allium brevistylum, Arnica latifolia, Epilobium angustifolium, Fragaria virginiana, Galium boreale, Lupinus argenteus, Moneses uniflora, Pyrola secunda, Thalictrum occidentale*

C = major climax species; S = seral; s = seral in some stands

Understory species that occurred on the nine spruce-fir plots listed by Despain (1973) include: *Cladonia* spp., *Peltigera* spp., Mosses, *Pyrola secunda, Arnica cordifolia, Arnica latifolia, Vaccinium scoparium, Epilobium angustifolium, Luzula parviflora, Carex* spp., *Frageria virginiana, Antennaria racemosa, Galium boreale.* Despain (1973) found that by far the greatest amount of ground cover is accounted for by lichens and mosses, 20-30%.

Successional Pathways, patterns

The following diagram, originally in Stahelin (1943), is still cited in recent publications, such as Knight (1994).

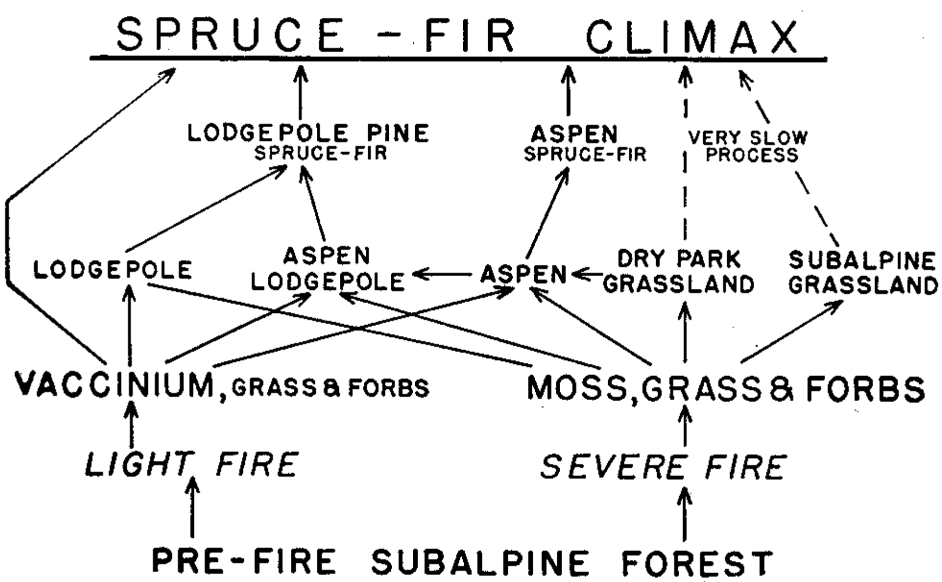


Figure 2.—Succession in subalpine forest after fire (Stahelin 1943).

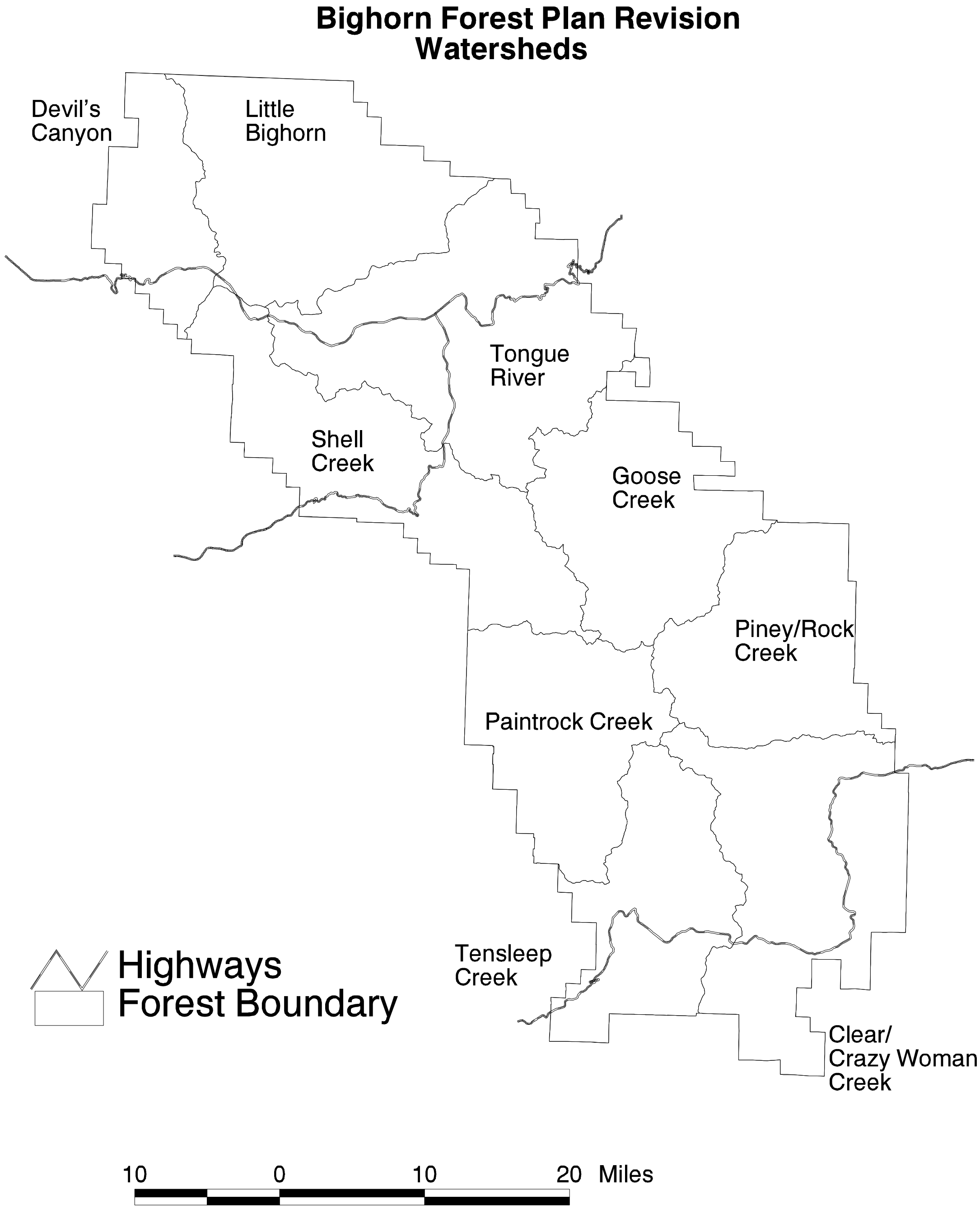
Differences in composition among stratification units

Table 4 above shows how the various forest species affinities for specific soil substrates on the Bighorn National Forest. Of the major forest types, spruce-fir is the most likely to occur on either sedimentary or granitic substrates.

The Bighorn National Forest has been stratified by watershed, see the watershed map on page 8. The following table shows how the cover types vary by watershed. The number of acres is the total acres, including lands of other ownerships, that occur within the proclaimed boundary of the Bighorn National Forest.

Table A4. Major Vegetation Types by Watersheds on the Bighorn National Forest

Watershed	Acres	Vegetation Cover Types				Forested Cover Types			
		Forest	Grass-forb	Non-Veg.	Shrub	Spruce-fir	Lodge-pole	Doug-fir	Other
Clear-Crazy	155,774	72%	13%	13%	2%	16%	79%	>1%	5%
Tensleep	101,130	59%	14%	17%	10%	29%	51%	19%	1%
Paintrock	107,944	52%	20%	20%	8%	38%	43%	15%	4%
Shell	140,130	49%	29%	7%	15%	40%	18%	36%	6%
Devil's	61,197	58%	22%	3%	17%	47%	13%	38%	2%
Little Bighorn	141,307	69%	22%	5%	4%	54%	12%	27%	7%
Tongue	177,069	69%	21%	3%	7%	37%	48%	7%	8%
Goose	116,953	80%	10%	10%	0%	26%	67%	4%	3%
Piney-Rock	110,255	79%	4%	17%	0%	27%	66%	1%	6%



Changes in species composition/anthropogenic influences/departures from HRV

Table A5 is from Table 7 in Meyer and Knight, November 2001 Draft Historic Variability for Upland Vegetation in the Bighorn National Forest, Wyoming for high elevation forests. This draft will be peer-reviewed by the Ecological Society of America. Meyer and Knight defined HRV for this study as "In general, we defined HRV as the range of means of a variable for several consecutive time periods during the historic period of 1600 to 1890…".

Table A5. Historic Range of Variability for Upland Vegetation on the Bighorn NF

	Stand Level		Landscape Level	
Variable	Within HRV	Outside HRV	Within HRV	Outside HRV
Disturbances				
Fire frequency	x			x
Fire intensity	x		x	
Fire size				x
Insect outbreaks	x		x	
Disease outbreaks	x-most	x-DM	x-most	x-DM
Blowdowns	x		x	
Structure				
Tree density	x		x	
Seedling/sapling density	x		x	
Percent canopy cover, rate of canopy gap formation		x		x-for 20 years
Density/spacing of canopy gaps		x	NA	
Understory density and cover	x		x	
Tree Species diversity	x		x	
Genetic diversity		x	x	
Diversity of all plants	x		x	
Age and size-class structure of stands	x-most	x-some		x
Snag density		x		x
Forest floor depth	x		x	
Mineral soil affected		x		x
Coarse woody debris		x		x
Number and proportion of land cover types			x	
Forest/nonforest ratio			x	
Proportion in different successional stages	NA		x-rest	x-old-growth
Proportion of land with low canopy cover	NA			x
Proportion of land with high density snags and CWD (= to young and old successional stages)	NA			x
Edge, interior, patch shape, patchiness	NA			x
Rate at which new patches form	NA			x

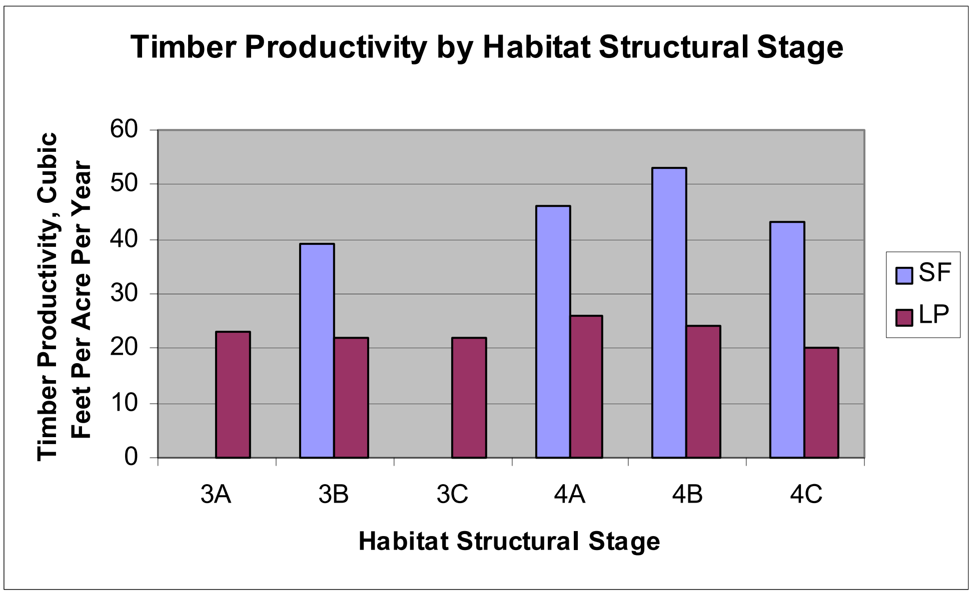
STRUCTURE AND FUNCTION

Cycling of carbon, nutrients (nitrogen), water, primary productivity

Bighorn Stage I inventory data reveals that existing spruce-fir forests occur on much more productive sites than does lodgepole pine. Table A6 shows that spruce-fir sites produce from 40 to 50 cubic feet per acre per year, while existing lodgepole pine sites produce between 20 and 25 cubic feet per acre per year.

Table A6. Timber Productivity of Existing Lodgepole and Spruce-fir

Forests in the Bighorn National Forest



Decomposition of dead trees is very slow, as evidenced in picture 2, which was taken in 1994. It shows an area in the Powder River watershed that was “dead timber” in 1901, so the coarse woody debris originally died in a stand replacing fire that occurred in about 1890, based upon the existing stand origin date.

Picture 2. 1994 photo of a lodgepole pine stand in the Powder River watershed that was "dead timber" in the 1901 Forest Reserve boundary survey

Habitat Structural Stage descriptions

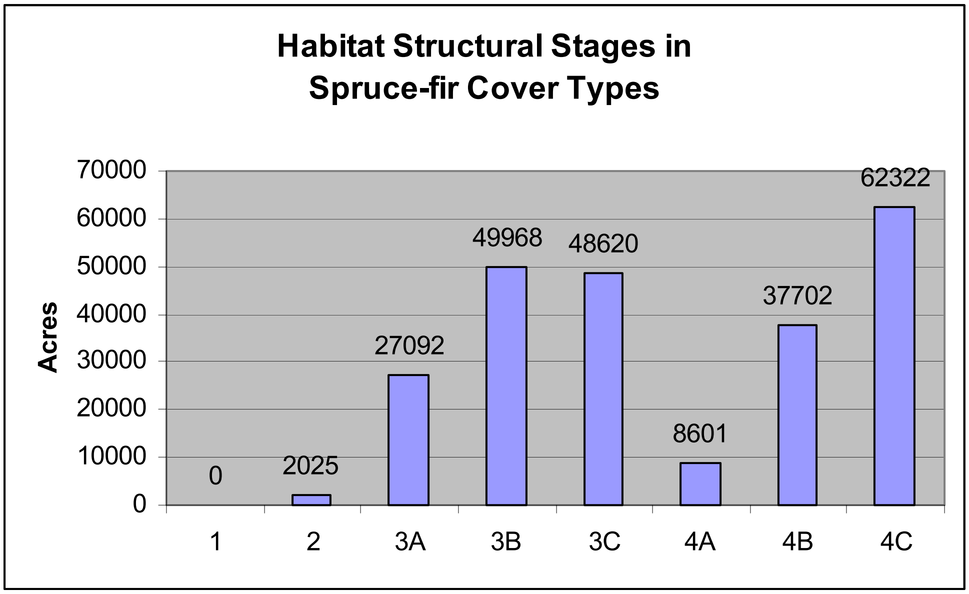
Habitat structural stage provides a "coarse filter" look at habitats provided by forests. It gives an indication of forest size and density, which can be interpreted for wildlife habitat suitability. Forested stands provide an infinite variety of tree sizes and canopy densities, and to consider the amount, type, and spatial distribution of wildlife habitats, people need a simplified system to comprehend this variety. Many habitat considerations, such as amount and type of understory vegetation; size and amount of snags and coarse woody debris; and, the amount of hiding cover provided, can be approximately inferred from the broad habitat groupings described in the habitat structural stage model.

Table A7 shows that the 4C structural stage covers the most acres in the current spruce-fir cover type. Spruce-fir is the only cover type where a 4 size class is the leading structural stages; the other cover types have a 3 size class structural stage covering the most acres. The B and C crown covers are much more prevalent than the low density A crown cover.

Habitat structural stages are defined in Hoover and Wills (1987). Structural stages describe the developmental stages of tree stands in terms of tree size and the extent of canopy closure. Structural stages can be considered a descriptor of the succession of a forested stand from regeneration, or bare ground, to maturity. For the purposes of describing wildlife habitat, forest structural stages are divided into four categories, consisting of Stage 1, grass/forb; Stage 2, shrub/seedling; Stage 3, sapling/pole; and Stage 4, mature, Table A8. It is important to recognize that structural stages represent succession in *forested stands* only; the grass/forb, structural stage 1, refers only to forested stands that have undergone a stand replacing event, and are temporarily in a "non-forested" condition. Structural Stage 1 does not include naturally occurring meadows. The letter in the structural stage naming convention (a, b, or c) refers to the crown density, Table A8.

Table A7. Spruce-fir Cover Type Wildlife Habitat Structural

Stages in the Big Horn Mountains



Data from Bighorn NF CVU database, 11/01. Includes all lands covered by CVU database.

Table A8. Habitat Structural Stage Definitions, Hoover and Wills 1987

Habitat Structural Stage	Diameter	Crown Cover %	Habitat Structural Stage	Diameter	Crown Cover %
1	Not applicable	0-10%	3C	1 – 9 inches	70-100%
2	< 1 inch	10-100%	4A	9+ inches	10-40%
3A	1 – 9 inches	10-40%	4B	9+ inches	40-70%
3B	1 – 9 inches	40-70%	4C	9+ inches	70-100%

A map of the spruce-fir wildlife habitat structural stages is included in the appendix.

Expected Range of coarse woody debris

Graham, et al., (1994) studied the amount of coarse woody debris (CWD) in various forested habitat types in the Intermountain Region. They used ecotmycorrhizae as a bioindicator of healthy, productive forest soils. For the Abies lasiocarpa/vaccinium scoparium habitat type, their recommendation was that 16.5 to 32.9 Megagrams per hectare (7.3 to 14.7 tons per acre) of CWD over 3.0 inches in diameter should be left on site following logging. These amounts may not represent the extremes of the historic range of coarse woody debris, but may be more of a mean over time.

Expected range of snag structure

Table A9 shows average snags per acre in spruce-fir forests on the Bighorn National Forest, based on 58 spruce-fir stands (564 variable-radius plots) of Stage I inventory data. Since these are per acre stand averages, they do not represent the range of snags that occurred historically.

Table A9. Average Snags per Acre in Spruce-Fir Stands on the Bighorn NF

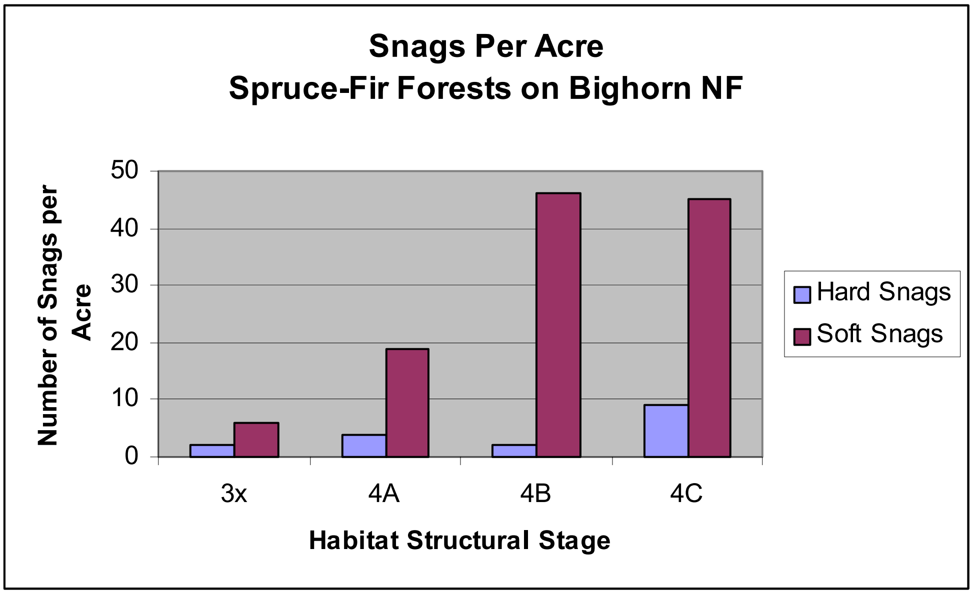


Table A10. Historic Range of Variability for Snags per Acre in Spruce-fir Forests on the Bighorn National Forest. (Bornong estimate)

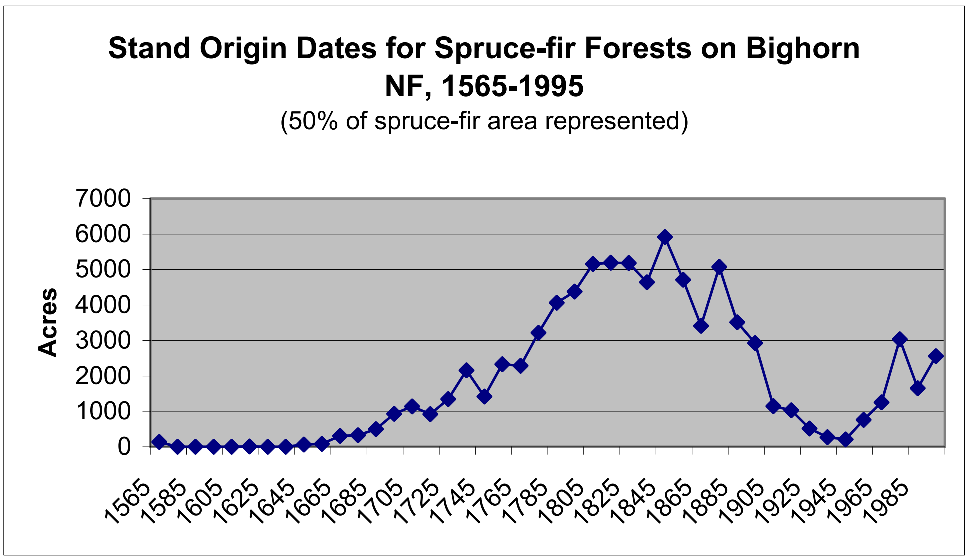
Number of Snags per Acre	Conditions Creating this Condition
Several thousand in all diameter classes	For 10 to 20 years following a stand replacing fire.
Near 0	For at least some stands, approximately 50 to 100 years following the stand replacing fire after the original snags fell over and before mortality began in the new stand.

Old-growth characteristics

The Bighorn NF is using the old-growth definitions in Mehl (1992) for various forest cover types specifically, and the old-growth definition in Kaufmann (1992) generically.

Table A11 shows the stand origin dates for spruce-fir forests on the Bighorn NF. Mehl (1992) cites that the minimum age for spruce-fir old-growth is typically 200 years old; approximately 15% of the spruce-fir area has stand origin dates before 1800. This information should be used carefully for two reasons. First, only 50% of the spruce-fir forest has stand origin data, so 15% is certainly less than the total amount of spruce-fir forest over 200 years old. Second, age is only one of approximately 9 criteria Mehl (1992) uses to describe spruce-fir old growth.

Table A11. Stand Origin Dates for Spruce-fir Forests on the Bighorn NF



The spike on the far right of table A11 represents timber harvests and fires between the 1960s and present. The dip in the data centered around 1935 and 1945 can be attributed to fire suppression.

Old growth forests on the Bighorn NF have been the subject of much public discussion over the past decade. Some of the facts associated with old-growth forests on the Bighorn:

- **The current amount of old-growth on the Bighorn NF, and the range of old-growth that existed on the landscape in the past, is unknown.** Meyer and Knight (2001, draft) list percentages in figure 43 that are incomplete and incorrect for old-growth. The percentages cited are from the RIS database, habitat structural stage 5, and are not considered to be complete or correct.
- **The amount of old-growth that historically existed on the forest fluctuated over time.** The fluctuations were probably large, based upon the large scale, periodic, disturbance events known to occur in this ecosystem. On the Bighorn, early reports and known age class distributions indicate that approximately 25 to 33% of the forested areas burned in the later half of the 19^{th} century. In Yellowstone National Park, about 50% of the park burned in 1988.
- **Two watersheds on the Bighorn have had extensive old-growth inventory work done in the past decade.**

  - In Clear Creek/Crazy Woman Creek, an extensive, although not complete, old-growth inventory found at least 5% of the forested area was old-growth. Based upon the thoroughness of that inventory and a general knowledge of the remaining portions of the watershed, it is estimated that an additional 2-3% of the forested area is old-growth. The two primary reasons for the small amount of old-growth is the large of amount of timber harvesting during tie-hacking and the past 4 decades, and the large area that burned around 1880.
  - In the North Fork of Powder River, a 10,000 acre watershed, old-growth inventories were halted after the inventory found that nearly every stand not harvested since logging began in the watershed in 1960 was old-growth. Surveys to that point revealed that 33% of the forested area in the watershed qualified as old-growth. An Engelmann spruce was found to be 550 years old, and a 500 year old lodgepole was found. In addition, Dennis Knight, during a field tour in 2001, noted that the 20 to 25 inch diameter lodgepole near the 500 year old tree were the largest he had seen.
- **Fire suppression may have increased the amount of old-growth forest and timber harvest has decreased the amount of old-growth forest currently existing.**

Within stand age class and diameter distribution characteristics, occurrence or abundance of large trees

Table A2, trees per acre by diameter class for spruce-fir habitat structural stage 4C and Table A3, basal area by diameter class in spruce-fir, show some relationships between diameter class distributions and tree size.

Engelmann spruce can attain diameters of up to 50 inches and heights of up to110 feet on the Bighorn NF. Subalpine fir can attain diameters of up to 25 inches and heights of up to 85 feet. Riparian areas and sedimentary soils are the locations of the largest trees in the spruce-fir type.

Stand densities

Table A2, trees per acre by diameter class for spruce-fir habitat structural stage 4C, is typical of stand densities for spruce-fir forests on the Bighorn. The data in Table A2 is presented below in Table A12.

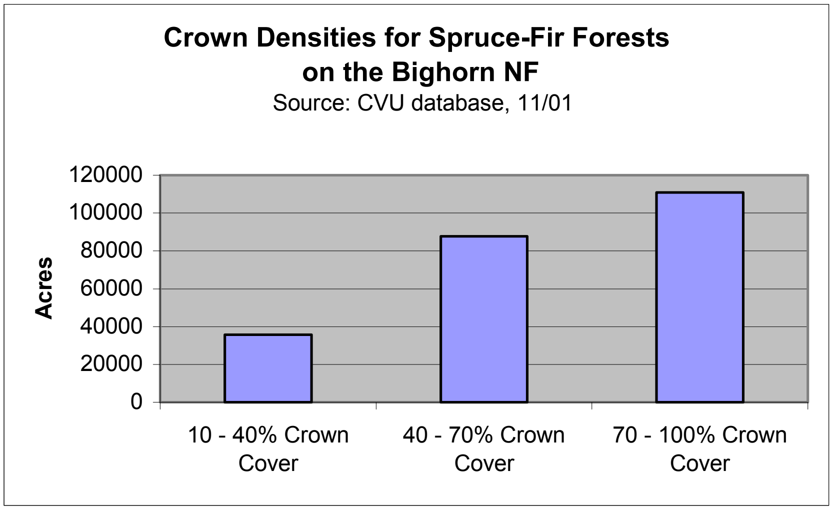
Table A12. Trees per acre for 9"+ stand average dbh spruce-fir on the Bighorn NF

Spruce-fir Habitat Structural Stage 4A						
DBH	**Sub. Fir**	**ES**	**LP**	**DF**	**Aspen**	**Other**
0	1143	222	57	120	50	3
1 - 4	134	38	3	4	5	0
5 to 8	40	28	6	2	1	4
9 to 15	15	34	13	1	0	1
16 to 20	0	6	1	1	0	0
21+	0	2	0	0	0	0
1"+	189	108	23	7	6	4
Spruce-fir Habitat Structural Stage 4B						
DBH	**Sub. Fir**	**ES**	**LP**	**DF**	**Aspen**	**Other**
0	1759	319	4	112	0	0
1 - 4	183	57	26	16	0	0
5 to 8	50	37	18	3	0	1
9 to 15	19	43	12	3	0	0
16 to 20	1	13	1	1	0	0
21+	0	6	0	0	0	0
1"+	252	155	57	23	0	1
Spruce-fir Habitat Structural Stage 4C						
DBH	**Sub. Fir**	**ES**	**LP**	**DF**	**Aspen**	**Other**
0	1191	273	0	0	0	0
1 - 4	228	103	18	0	0	0
5 to 8	104	139	32	0	0	11
9 to 15	15	82	19	5	0	3
16 to 20	0	8	1	2	0	0
21+	0	6	1	1	0	0
1"+	347	338	71	8	0	14

Canopy closure

Table A13 shows the crown densities for spruce-fir stands on the Bighorn NF. This table is from the CVU database, and includes all spruce-fir stands in the habitat structural stage 3 and 4 size classes.

Table A13. Crown Densities for Spruce-fir Forests on the Bighorn NF



Patchiness

Spruce-fir stands on the Bighorn National Forest are naturally patchy in terms of species composition and tree density.

- Patchiness is considered to increase with increasing stand age.
- As seral lodgepole pine succeeds to spruce-fir, species patchiness increases initially, then decreases as the lodgepole dies out.
- Old spruce-fir stands on the Bighorn are typically patchy as the majority of within stand disturbance events are at an individual tree or small group of trees scale. That is, between the infrequent (300 to 500 year interval) stand replacing event, individual tree/group mortality caused by insects and/or diseases create small canopy gaps that give rise to an uneven-aged structure.

Vertical complexity

Using tree diameters as an indirect proxy for vertical complexity, Table A12 shows a fully occupied vertical structure in the spruce-fir forests on the Bighorn. The fact that the species are spatially distributed throughout these stands, and they typically are uneven-aged, only support the conclusion that spruce-fir stands on the Bighorn are multi-storied.

Changes in structure/anthropogenic influences

Table A14. Spruce-fir Timber Harvest History on the Bighorn NF

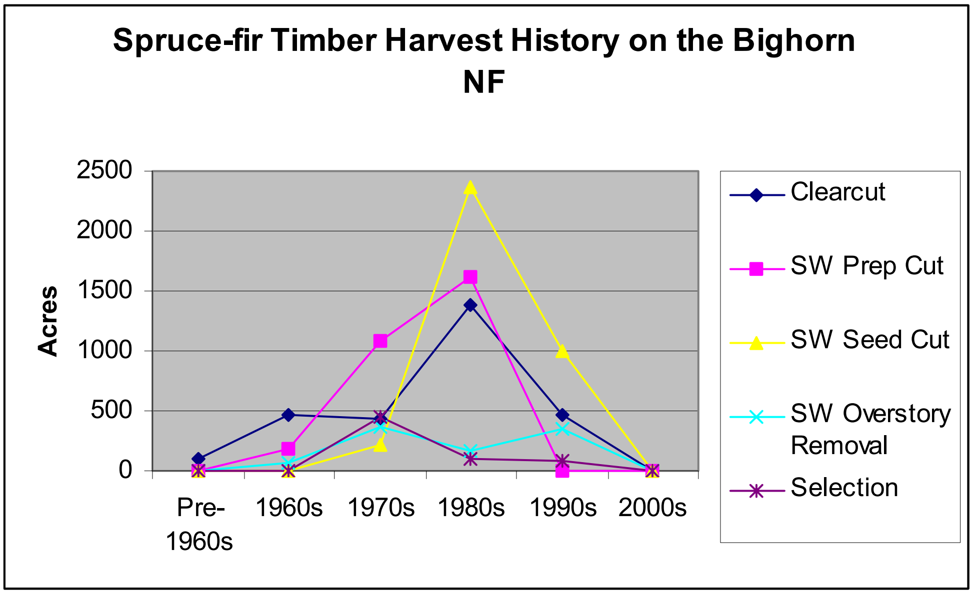


Table A15, showing activities in spruce-fir forests on the Bighorn NF, should be interpreted with the following caveats:

- The data for silvicultural activities is considered to be accurate from the 1960s on.
- The fire data is not the most accurate available; the large fire coverage is more accurate for fire acres than this data.
- This table over represents the total acreage of timber harvest activities, since some areas received more than one event, and this table lists all activities that occurred. For example, some stands that were burned were subsequently logged under a sanitation/salvage prescription.

Table A15. Activities in Spruce-fir cover type on the Bighorn NF

Activities in Spruce-fir cover type on Bighorn NF							
	Pre-1960s	1960s	1970s	1980s	1990s	2000s	Total
Clearcut	98	470	437	1377	475	0	2857
SW Prep Cut	3	177	1089	1612	5	0	2886
SW Seed Cut	0	0	216	2371	1003	0	3590
SW Overstory Removal	0	75	373	159	352	0	959
Selection	0	0	442	100	78	0	620
Seed Tree	787	0	0	0	5	0	792
Selection	0	0	442	100	78	0	620
Commercial Thin	0	17	545	140	59	0	761
Sanitation/Salvage	0	0	245	1863	884	0	2992
Pre-Commercial Thin	0	0	25	937	432	0	1394
Fire	17	0	979	4266	44	0	5306
Blowdown	0	0	0	8	1059	0	1067
Total	1055	2699	6763	14913	6464	0	23844

Data source: RMACT activity region coverage, 11/2001.

Some of the interpretations that can be made from this table include:

- 1% of the spruce-fir cover type has been clearcut since 1960.
- Based on the information in this table, approximately 10% of the spruce-fir forests have had some sort of "activity" in the past 40 years.
- The rate of silvicultural activity (activities other than fire and blowdown) has slowed over the past decade, going from a total of 8659 acres in the 1980s to 3288 acres in the 1990s. Most of the 1990s silvicultural activity occurred prior to 1994.

Figure 42 is from Tinker, et al (1998), and portrays how timber harvest over the past 50 years and roads have changed various landscape variables when compared to a "base" landscape. A four step process was used to quantify this landscape change:

1. BASE, the black dot, is the base landscape without clearcuts and roads. It includes fires and blowdowns. Clearcuts and roads were added back into the landscape to make BASE.
2. The second map was the same as BASE, but added existing roads. This layer was called BASERD, and is shown in figure 42 as a black triangle.
3. The third map was the same as BASE, but added existing clearcuts. This layer was called BASECT, and is shown in Figure 42 by the open square.
4. The final map was the same as BASE, but added both existing roads and clearcuts. This layer was called BASECTRD, and is shown in Figure 42 by the open tilted square.

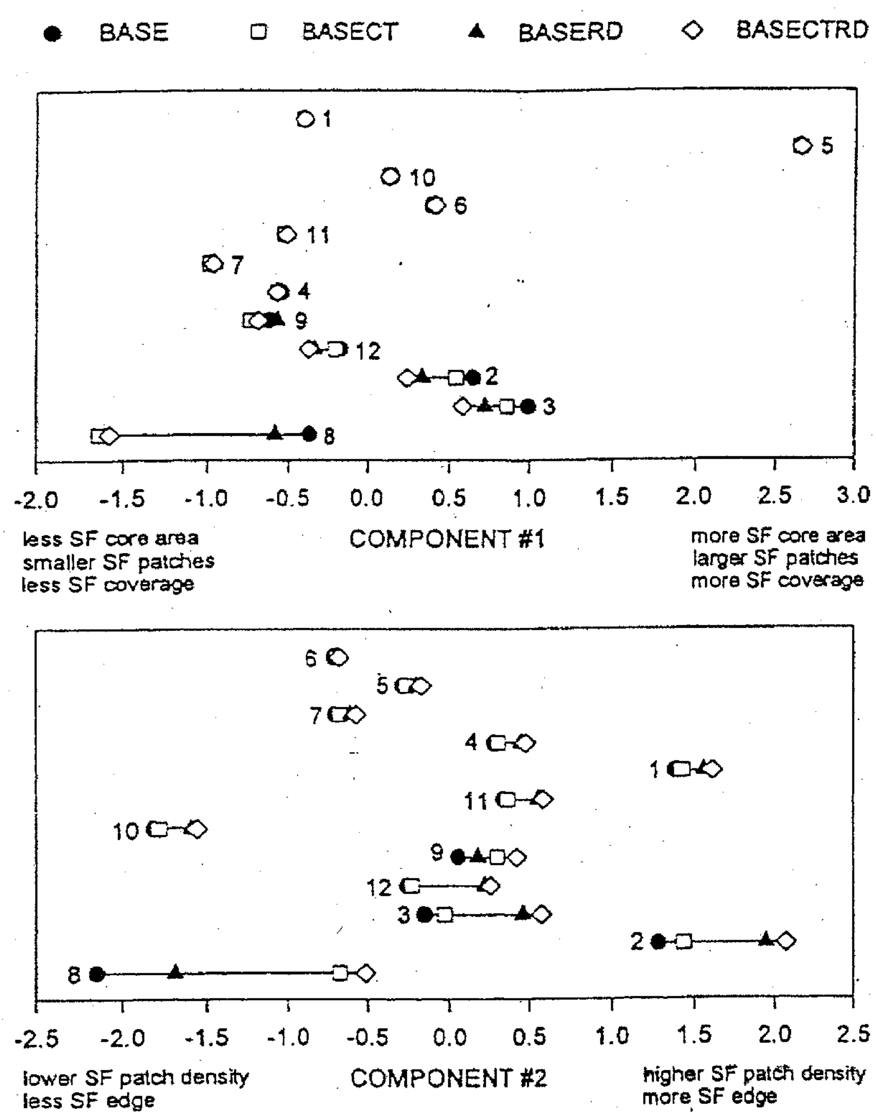


Figure 42. Scores on the first two principal components of spruce-fir forest (SF) variables for each watershed on the Bighorn National Forest. The components are correlated to several landscape variables indicated on the bottom of graph. Numbers adjacent to the symbols indicate watershed number. The symbols represent each type of map analyzed. BASE = map with no human disturbances, BASECT = rnap with clearcuts added, BASERD = map with roads added, BASECTRD = map with roads and clearcuts added.

Interpretations from Figure 42 include:

- The spruce-fir forests in some watersheds have been changed, while others are largely intact.

- Roads have been a larger impact than timber harvest, except for the Crazy Woman Creek watershed (number 8).